Operational training for foreseen and unforeseen events

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Content

- Theory – required competencies for foreseen and unforeseen events
- Nuclear power plant operations, as reference (field study)
- Training approach in NPP operations
  - Traditional training
  - Adaptive training

Theory

Foreseen events

Proceduralized (in details)

Required competence

Routine expertise

Using procedures in standard situation

Unforeseen events

Not proceduralized in details

Required competence

Adaptive expertise

Global understanding.
Non standard situations

(Hatano and Inagaki, 1986)

NPP Operations in a Nordic Plant: A Field Study

(Re-Analysis)

Purpose:
Original: What are the similarities and differences in teamwork competence requirements in operations crew across three operational states? (Skjerve and Holmgren, *in* progress)

Revisited to *explore*: **What competencies in promote handling of unforeseen events in NPP operations?**

(Skjerve, Holmgren, Widheden, *in progress*)

Data collection: Period: 2012-2014

Data type	Details
Observations	**NORMAL** operation: 57hs **OUTAGE**: 50hs **EMERGENCIES**: 6ds of continuing training Numerous conversations.
Interviews	2 shift managers, 5 control-room operators, 3 field operators, 1 unit manager, 2 outage managers
Questionnaire survey	33 operations crew members.

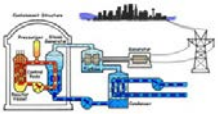
Data Analyses

Thematic analysis approach (Braun and Clarke, 2006)

- ID data describing or exemplifying adaptation
- Structure into main themes.
- Reviewed by third author.

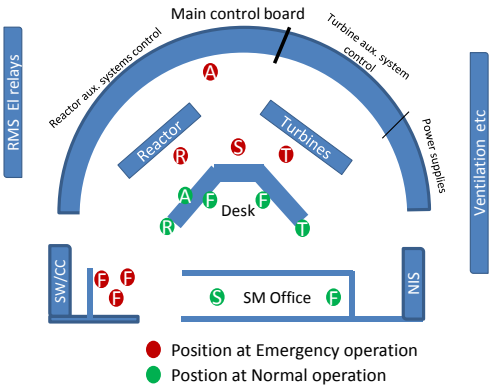
All specific references to NPP operations refer to the targeted plant.

Nuclear Power Plant Operations



Source: Wikipedia.

PWR



The operational activity is highly proceduralised

Operating procedures are based on:

- Technical requirements associated with operation of equipment
- Strategies for mitigating plant events.

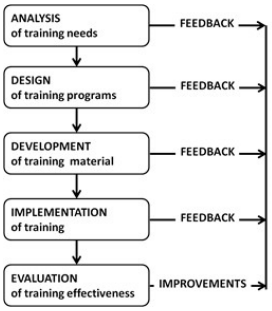
Traditional Training Approach (1/2)

Overall:

- Systematic Approach to Training (SAT)
- Job-Task Analysis (IAEA, 1996)
- Purpose: Plant operation based on the operating procedures.
  - Learning the procedures for standard tasks
  - Correct implementation.
- Discrete sessions

Initial training:

- System functions and dependencies
- Normal and Emergency operations
- Basic technical competencies (*)



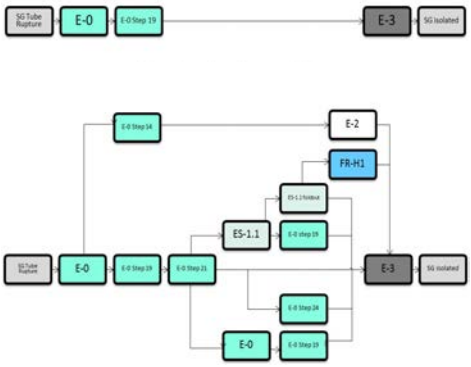
SAT (IAEA, 1998)

(*) Including, e.g., thermodynamics-hydraulics, heat transfer and fluid mechanics, mechanics and materiel strengths, and to a certain extent electricity and electronics. To a some degree assumed.

Traditional Training Approach (2/2)

Continuing training (6-years cycle)

- *Repetition*: Each of the most important EOPs will be trained at least once pr. 6 years.
- *Overlearning*: Procedure for identification & steam generator tube rupture; secondary break, loss of coolant.
- *Compliance*: General policy: "Procedures should be adhered to and signed off" - feedback focused on, among other things, compliance.
- *Teamwork*: Adequacy, adaptation.



Implying Adaptive expertise

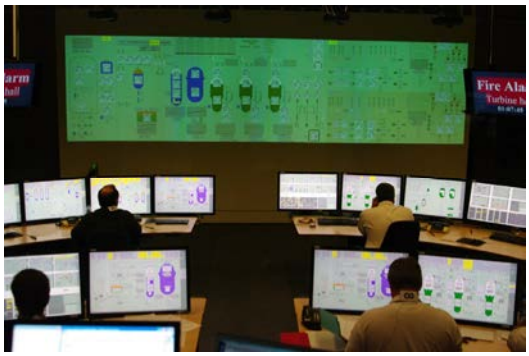
Halden Man-Machine Laboratory

Typical feedback from operators:

It's useful to be here. The scenarios are different from what we usual train. We learn a lot.

Characteristics

- Challenging scenarios (non-standard, multiple failures)
- Realistic



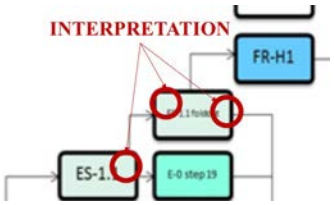
Findings:

- "… scenarios with multiple malfunctions and/or unreliable indications should be trained more often…" (Massaiu and Holmgren, 2014, 61)

Adaptive Training Approach

→ Increase focus on the development of adaptive expertise

- Systematic Approach to Training (SAT): Job-Competence Analysis
  - The specific task associated with unforeseen situation is unknown
- Purpose: Promote handling of unforeseen operating events by adapting procedures and developing new strategies.
  - Promote the ability to build a global situation understanding, to interpret data, and to make the best possible use of available options.
- Continuous



Using procedures involves interpretation.

Main ref.: Hatano and Inagaki (1986); Smith et al. (2002).

Competence Dimensions

	Important competencies for adaptive expertise in NPP operations crew.
1	Mental preparedness for the unforeseen.
2	Making sense of the process system's state (working mental model).
3	Involving the right people.
4	Decision making in unusual, dynamic contexts.
5	Continuous performance adaptation.
6	Making the most of available technologies.
7	Directing one's own performance and strategies (meta-cognition).
8	Staying power.

Δ

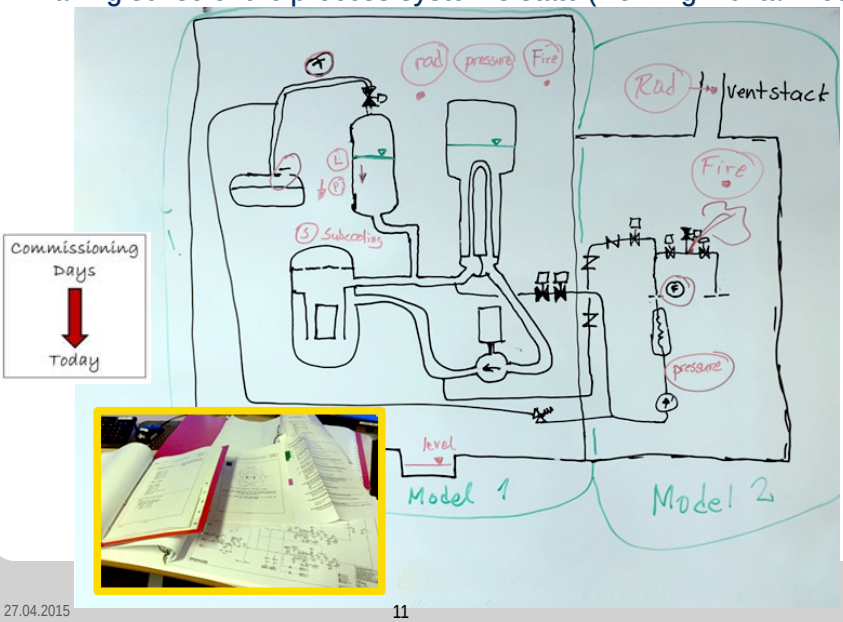
Competence: **skills**, **knowledge** and **attitudes.**

Note: Not all of the dimensions need to be relevant in every unforeseen situation

(Skjerve, Holmgren, Widheden, *in progress*)

Competence Dimensions, details

Making sense of the process system's state (working mental model)



Competence Dimensions, details

Events (extract)

Scene: Early Christmas Morning 05:00am. The operations crew has finished their Christmas Meal. Operators are in the CCR, Field operators out in the plant on safety rounds:

- **5:07am**: Out of nowhere, alarms from reactor and turbine. RO: "High steam flow SGs 2 og 3".
- Mechanically, start to check SG instrumentation: Steam line isolation valve from SG1 apparently no longer open….
- ARO tries in vain to open the valve. Simultaneously alarms from the electricity board, high rumblings and weak vibrations are heard and felt – and the reactor tripped.
- Strive to keep focus; to not be overwhelmed.
- Start going though the identification procedure
- A FO reported that an air membrane belonging to the steam line isolation valve had cracked!
- Relief that it was "only" a scram.
- Stabilizing the plant, now much calmer and very focused
- 05:20am: SM calls Engineer on Duty
- **05:45am**: Plant stabilized.

Scene: Afternoon shift. The operators are in the control room. Some field operators are in the control-room, and some work out in the plant.

- **08:00pm**: A series of alarm sounds from train X: First from the battery room, then from the rectifiers, and then from the room for power distribution of safeguard equipment.
- As specified in the procedures: Crew called the fire department and send FO's to the compartments, and started preparing for reactor trip, disconnection of power supply, and fire extinguish actions. If the procedures had been followed to the letter, the *reactor should now have been tripped……*
- FO reports: light smoke, smelled burnt.
- SM judges it is too drastic to trip the reactor there and then, and after briefing the crew, they decide to wait
- Investigate the ventilation system and the fan room.
- Fire due to overheating and breaking down bearing from one of the fans.
- Fan stopped, doors open to ventilate rooms.
- Fire department. cancelled.
- **08:30pm**.

Training aimed at developing Adaptive Expertise to handle unforeseen events (1/3)

Routine Expertise
FORESEEN EVENTS

Adaptive expertise
UNFORESEEN EVENTS

Task performance based on procedures

More and more practice

Faster, more accurate, automatic and inflexible performance

New procedures with shared components are learned faster

Critical thinking
Why and how

Why is the procedures written as they are?
When will the procedures not work?
Can the task be solve in alternative ways?

(Hatano and Inagaki, 1986);

Training aimed at developing Adaptive Expertise to handle unforeseen events (2/3)

Routine expertise

Adaptive expertise
UNFORESEEN EVENTS

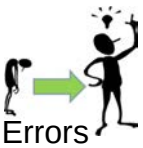
Critical thinking
Why and how

Constructivist learning principles
- Discovery learning
- Error-based learning

Abstractions, facilitate transfer across situations.

Knowledge structure
Meta-cognition

Experimentation — Exploration

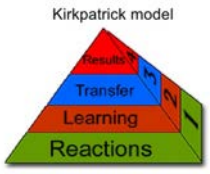


Hatano and Inagaki (1986); Smith et al. (2002).

Training aimed at developing Adaptive Expertise to handle unforeseen events (3/3)

Evaluation of the training program 's effect

- Training goal with fuzzy boarders
- Performance in one specific novel scenario, need not predict performance in another novel scenario
- Outages, might be the best testbed for *Transfer*



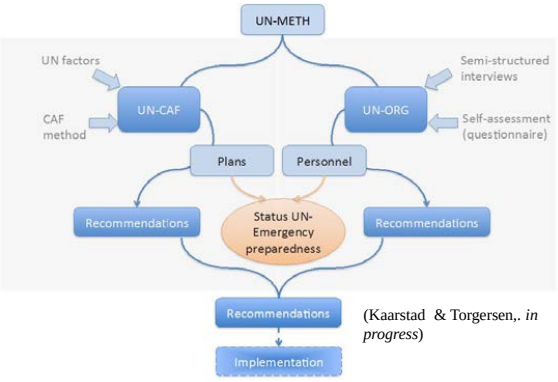
Promote continuous development of adaptive expertise

Work practice	Current: When an error, only write what is observed. Alternative: Request crew to assess the reason for the error.
On-the-Job Training	Current: EOPs often refreshed by reading them aloud. Alternative: Walk-through the procedures in the control-room and in the plant in as realistic conditions as possible, with no manoeuvring. Insights into the time and resources needed to handle emergencies.
Self-assess.	Availability of a competence self-assessment tool.

Culture for Safety & Learning

Culture for Safety and Learning

- Plant management support
- Organization of everyday work
- Expanding continuing training (today ≈ 10%)



(Kaarstad & Torgersen,. *in progress*)

New tools and methods might be called for:

- Training materials, e.g. computer-based training; Sense-making tools; Self-assessment.

Rounding Off

High levels of complexity in safety-critical production systems, increase the likelihood for unforeseen events

Severe accidents

- Fukushima, could it happen here?
- "Distancing Through Differencing" (Cook and Woods, 2006)

Training addressing the unforeseen in safety-critical systems

- Can't the safety system guarantee that we are always protected against the risks?
- Recognizing that we cannot foresee all events, but that we can prepare to protect against unforeseen events.

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